Attorney Docket: 4834/PCT
INV.: E[illegible]t FISCHER et al. 10/522038

Official ref: PCT/EP03/06694

DT15 Rec'd PCT/PTO 18 JAN 2005.

ACCURATE TRANSLATION OF ANNEXES OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

Method for assisting a driver when performing driving maneuvers

The invention relates to a method for assisting a driver when performing driving maneuvers, according to the preamble of patent claim 1.

Such a method is known from FR 2 758 383 A1. In order to park, a trajectory from a starting to a target position, having turning points or turning zones, is calculated there. If the vehicle, in traveling along the trajectory, is located at such a turning point or in such a turning zone, the vehicle is retarded or stopped. The vehicle can be kept at a standstill until the driver has set the steering angle which is predefined by the next section of the trajectory as far as the next turning point, as viewed in the direction of travel.

Furthermore, DE 198 09 416 A1 discloses a method for assisting the driver when parking. During the driving maneuver, the parking strategy is communicated to the driver via an optical display device, an acoustic speech output device or a tactile steering wheel, so that the driver can park in the parking gap, following the parking strategy.

Furthermore, it is known, for example from DE 197 45 127 A1, to initiate an automatic braking operation when the distance between the vehicle and an object

AMENDED SHEET

USPS EXPRESS MAIL
EV 511 024 797 US
JANUARY 18 2005

falls below a limiting value. The intention is to avoid a collision with the obstacle in this way.

The generic method has the disadvantage that the reactions of the driver to the instructions about the steering wheel position to be set cannot be predicted. The driver is incorporated in the control loop and, so to speak, represents a disturbance variable. In particular during difficult driving maneuvers, such as reverse parking into a parking gap at the edge of the road, parallel to the edge of the road (what is known as parallel parking), it is difficult for the driver to set the steering wheel position respectively requested by the instruction during the driving maneuver.

It is therefore the object of the present invention to develop a method and a device for implementing the method of the generic type in such a way that it is made easier for the driver to set the steering wheel position requested by means of the instruction.

This object is achieved by the features of patent claims 1 and 13.

According to the invention, the vehicle longitudinal speed is influenced independently of the driver when there is a steering angle deviation between the actual steering angle actually set by the driver via the steering wheel and the desired steering angle corresponding to the requested steering wheel position. In this case, the influence on the vehicle longitudinal speed depends on the magnitude of the steering angle deviation. The greater the steering angle deviation, the more intensely will the vehicle be retarded in order to reduce the vehicle longitudinal speed.

If there is such a steering angle deviation, then, during the driving maneuver, the vehicle departs from the ideal line predefined by the reference trajectory. The vehicle longitudinal speed is then reduced in order to provide the driver with sufficient time to steer the vehicle again into a vehicle position predefined by the reference trajectory.

Advantageous refinements of the method according to the invention and the device according to the invention emerge from the dependent patent claims.

During the driving maneuver, depending on the actual vehicle position, a steering angle tolerance band defining the permissible steering angle can be determined and the influence on the vehicle longitudinal speed can depend on the tolerance margin

car drivers or for car drivers who are not used to a new or seldom used vehicle. They are quite generally driving maneuvers with a vehicle longitudinal speed below a speed threshold value of, for example, 10 km/h.

It is furthermore of advantage if, in the case of a vehicle in trailer operation, each vehicle position along the reference trajectory is assigned a desired trailer angle between the vehicle longitudinal axis and the trailer longitudinal axis and if the actual trailer angle is determined and compared with the corresponding desired trailer angle, in the event of an angular deviation between the desired trailer angle and the actual trailer angle, the vehicle longitudinal speed being influenced independently of the driver. Here, an angular deviation between the desired trailer angle and actual trailer angle is additionally taken into account. In addition, in the event of the angular deviation between the actual trailer angle and the desired trailer angle, speed control can be carried out as a function of the magnitude of the angular deviation. Furthermore, it would also be possible to select the driver-independent vehicle retardation to be greater, the greater the magnitude of the angular deviation.

In the following text, the invention will be explained in more detail by using the appended drawings, in which:

fig. 1 shows a schematic representation of a desired trajectory for a parking maneuver in plan view,

fig. 2 shows a representation in a manner of a block diagram of an exemplary embodiment of a device for assisting the driver when performing a driving maneuver,

figs 3a-3c show a first embodiment of an optical display for the steering wheel position to be set for the driver,

A further embodiment of an optical display for requesting a steering wheel position to be set is shown in fig. 5. There, the vehicle wheels 34 of the steerable front axle 35 are illustrated schematically. The wheel position represented by the continuous lines is the actual wheel position 36 of the vehicle wheels 34, while the dashed illustration indicates the requested desired position 37 of the steered vehicle

wheels 34. Accordingly, the driver must displace the steering wheel into a position in which the desired position 37 of the vehicle wheels 34 coincides with the actual wheel position 36.

It goes without saying that, instead of the different illustration of desired position 37 and actual wheel position 36 of the vehicle wheels 34 by lines, different colors can also be chosen, if the display device 13 has a color LC display.

It is not just possible to use one or more of the optical display possibilities described in order to specify the steering wheel position to be set to the driver, but, furthermore, alternatively or additionally, acoustic driver information and/or tactile driver information which specifies the steering wheel angle to be set can be provided.

The acoustic driver information can be provided, for example, by means of a speech output via loudspeakers in the vehicle, not specifically illustrated. Tactile driver information in the exemplary embodiment is provided by using force or torque feedback on the steering wheel 40. For this purpose, the evaluation device 12 is connected to a servo motor 41 of the power steering system 42 in order to drive the latter, as indicated in fig. 2 by the dashed line 43. Thus, the steering wheel torque at the steering wheel 40 can be varied by the evaluation device 12 via the servo motor 41 for the purpose of tactile driver information about the steering wheel angle to be set. It is possible in this case to increase the steering wheel torque to be applied by the driver for a direction of rotation away from the requested steering wheel position and/or to reduce the steering wheel torque to be applied by the driver in a position of rotation toward the requested

steering wheel position. Consequently, the driver can experience, through the steering wheel torque to be applied, the direction of rotation in which he must move the steering wheel in order to set the requested steering wheel position, by which means tactile driver information for indicating the steering wheel position to be set is implemented.

During the driving maneuver, depending on the respective actual vehicle position $x_{F,act}/y_{F,act}/\psi_{F,act}$ the positional deviation of the vehicle 10 from that determined by the reference trajectory 16, and displayed to the driver by means of the display device 13, the steering wheel position to be set which reduces the positional deviation is displayed, so that the vehicle is again brought on to a travel route corresponding to the reference trajectory. As an alternative to this, it is in principle also possible to control out the positional deviation automatically.

The actual vehicle position $x_{F,act}/y_{F,act}/\psi_{F,act}$ of the vehicle 10 is to be understood not just as the vehicle position $x_{F,act}/y_{F,act}$ in the coordinate plane in relation to a stationary coordinate system 22 of the road 20; instead the vehicle position also includes the alignment of the vehicle longitudinal axis 71 in relation to the coordinate system 22. According to the example, the rotational angle ψ_F is formed between the y axis of the coordinate system 22 and the vehicle longitudinal axis 71. The desired rotational angle consequently corresponds to the tangent to the reference trajectory 16.

At the start and during the driving maneuver, in the direction of travel 18 of the driving maneuver, a right-hand limiting trajectory 23 and a left-hand limiting trajectory 24 are additionally calculated in

the evaluation device 12. The limiting trajectories 23, 24 depend on the actual vehicle position $x_{F,act}/y_{F,act}/\psi_{F,act}$. As viewed in the direction of travel 18 of the driving maneuver, they indicate the two trajectories along which the vehicle 10 can still just be steered to the target position 17 from the actual vehicle position $x_{F,act}/y_{F,act}$. The right-hand limiting trajectory 23 is obtained by successively increasing the actual rotational angle $\psi_{F,act}$ - in the mathematically positive sense - as far as an upper limiting rotational angle $\psi_{F,max}$, with which a trajectory, the right-hand limiting trajectory 23, to the target position 17 can still just be calculated. In this case, the values of the actual vehicle position $x_{F,act}/y_{F,act}$ remain unchanged.

The lower limiting rotational angle $\psi_{F,min}$ is determined in an analogous way by the actual rotational angle $\psi_{F,act}$ being reduced successively until the left-hand limiting trajectory 24 to the target position 17 can still just be determined.

This results in the following equations:

$$\psi_{F,max} = \psi_{F,act} + \Delta\psi_L \quad \text{and}$$
$$\psi_{F,min} = \psi_{F,act} - \Delta\psi_R$$

where $\Delta\psi_L$ indicates the value by which the actual angle of rotation has been increased, and $\psi\Delta_R$ indicates the value by which the actual angle of rotation has been reduced in order to obtain the relevant limiting rotational angle.

These limiting trajectories 23, 24 are determined, for example, by the algorithm used to calculate the reference trajectory 16. According to the example, the limiting trajectories 23, 24 are determined cyclically

during the driving maneuver. In order to reduce the computational effort, one limiting trajectory 23 or 24 is calculated during a computational cycle and the respective other limiting trajectory 24 or 23 is calculated during the following computational cycle. The accuracy in this procedure is completely adequate. As compared with the algorithm used for determining the reference trajectory, further simplifications can be permitted in order to reduce the computational effort. For instance, the limiting trajectories can merely be assembled simply from path curves, such as circular sections, which require less computational effort.

By using figures 6a and 6b, the following text will explain how the vehicle longitudinal speed v is influenced if a steering angle deviation d_{LW} occurs between the actual steering angle δ_{act} actually set by the driver and the steering wheel position requested and to be set corresponding to the desired steering angle δ_{des}.

At the time being considered, the vehicle 10 is in the actual vehicle position which is described by the values $x_{F,act}/y_{F,act}/\psi_{F,act}$ in relation to the coordinate system 22 of which the origin is located in the starting position 15. By using this actual vehicle position $x_{F,act}/y_{F,act}/\psi_{F,act}$, the determination of the upper limiting rotational angle $\psi_{F,max}$ and of the lower limiting rotational angle $\psi_{F,min}$ will be explained.

The actual vehicle position $x_{F,act}/y_{F,act}$ remains unchanged during the determination of the two limiting angles of rotation $\psi_{F,max}$, $\psi_{F,min}$. The vehicle 10 is, so to speak, rotated virtually about its vertical axis in this position until the relevant limiting rotational angle is reached from which it is still just possible to determine a trajectory - which means a possible

travel path of the vehicle 10 - specifically the relevant limiting trajectory 23 or 24 to the target position 17.

First of all, assume that the vehicle is rotated to the right about its vertical axis (in the mathematically negative sense) until the actual rotational angle $\psi_{F,act}$ is reduced by $\Delta\psi_R$, so that the vehicle longitudinal axis assumes the position designated 71' in figure 6a. The vehicle longitudinal axis 71' forms the lower limiting rotational angle $\psi_{F,min}$ with the y axis of the coordinate system 22. The right-hand limiting trajectory 23 resulting in this vehicle position, as viewed in the direction of travel 18 of the driving maneuver, is illustrated in figure 6a.

As an alternative to the use of a Gauss function, a triangular function or any other desired curved shape with the vertex δ_{des}/v_0 could also be used. This function can in particular be determined empirically in driving trials in order to set the desired driving feel.

In the exemplary embodiment, the vehicle longitudinal speed v is regulated on the basis of the actual steering angle δ_{act} or the steering angle deviation d_{LW}. This is carried out by activating retardation means 50 and/or forward drive means 51 of the vehicle 10.

In the exemplary embodiment according to fig. 2, the retardation means 50 are formed by a braking device 52 which a brake control unit 53 and wheel braking devices 54 activated by this brake control unit 53, which are assigned to the vehicle wheels 55 of the rear axle of the vehicle, and wheel braking devices 56, which are assigned to the vehicle wheels 34 of the front axle 35 of the vehicle 10. In order to activate the braking device 52, the evaluation device 12 is connected to the brake control unit 53.

As an alternative to speed regulation, the vehicle longitudinal speed v can merely being reduced by bringing about a braking pressure, without regulating the speed to a desired value, starting from the maximum speed v_0, which can be about 5 km/h, in the event of there being a steering angle deviation d_{LW}.

For the purpose of the vehicle retardation, alternatively to or simultaneously with the activation of the braking device 52, the forward drive means 51 are activated. For this purpose, the evaluation device 12 is connected to the engine control device 60, illustrated schematically in fig. 2, which here symbolizes the forward drive means 51. For reasons of clarity, the complete drive train with engine control device 60, the vehicle engine, the transmission, the drive shaft and so on, have not been illustrated.

The method according to the invention can also be used in a modified form for driving maneuvers of the vehicle 10 with a trailer 70. In this case, alternatively or additionally to influencing the vehicle longitudinal speed v on the basis of the steering angle deviation d_{LW}, the vehicle longitudinal speed v can also be influenced on the basis of the trailer angle deviation between a desired trailer angle β_{des} and an actual

trailer angle β_{act}. The trailer angle β is formed between the vehicle longitudinal axis 71 and the trailer longitudinal axis 72 (see fig. 7). For reasons of improved clarity, the trailer coupling and the trailer towbar for connecting the vehicle 10 to the trailer 70 are not illustrated in fig. 7.

In the case of trailer operation, each vehicle position of the vehicle 10 to be passed through along the reference trajectory 16 is assigned a corresponding desired trailer angle β_{des}. The simplest example would be the movement of the vehicle 10 with the trailer 70 straight backward, so that the desired trailer angle β_{des} is equal to zero during the entire driving maneuver.

The vehicle 10 has means for determining the desired trailer angle β_{des}, which, according to the example, are contained in the evaluation device 12. Furthermore, the vehicle 10 and/or the trailer 70 has/have means, not specifically illustrated here, for determining the actual trailer angle β_{act}. For example, the trailer angle between a vehicle 10 and trailer 70 can be registered by means of trailer angle sensors known per se.

DaimlerChrysler AG 10.21.2004

New Patent Claims

1. A method for assisting the driver of a vehicle (10) when performing a driving maneuver formed by a parking or shunting maneuver, a reference trajectory (16) corresponding to the driving maneuver being determined, along which the vehicle (19) is to be moved, and the steering wheel position to be set in each case and controlling the vehicle (10) along the reference trajectory (16, is 19) being indicated to the driver during the driving maneuver, the vehicle longitudinal speed (v) being influenced independently of the driver in the event of a steering angle deviation (d_{LW}) between the actual steering angle (δ_{act}) actually set by the driver and the desired steering angle (δ_{des}) corresponding to the requested steering wheel position, characterized in that the vehicle longitudinal speed is influenced on the basis of the magnitude of the steering angle deviation (d_{LW}) in such a way that the greater the vehicle retardation carried out, the greater the magnitude of the steering angle deviation (d_{LW}).

2. The method as claimed in claim 1, characterized in that, during the driving maneuver, depending on the current vehicle position ($x_{F,act}/y_{F,act}/\psi_{F,act}$), a steering angle tolerance band (δ_{min} to δ_{max}) which determines the permissible steering angle is determined and the influence on the vehicle longitudinal speed (v) depends on the tolerance margin (δ_{des} - δ_{min} or δ_{max} - δ_{des}) between the desired steering angle (δ_{des}) and the tolerance band limits (δ_{min} or δ_{max}).

AMENDED SHEET

3. The method as claimed in claim 2, characterized in that, in order to determine the steering angle tolerance band, a rotational angle tolerance band is determined, the actual rotational angle ($\psi_{F,act}$) between the vehicle longitudinal axis (71) and a coordinate axis (y) of a stationary coordinate system (22) being enlarged or reduced until it is just still possible to determine a trajectory to the target position (17).

4. The method as claimed in Claim 2 or 3, characterized in that the vehicle longitudinal speed (v) is chosen to be lower, the smaller the magnitude of the tolerance margin (δ_{des}-δ_{min} or δ_{max}-δ_{des}).

5. The method as claimed one of claims 1 to 4, characterized in that the vehicle longitudinal speed (v) is chosen to be lower, the greater the magnitude of the steering angle deviation (d_{LW}).

6. Method as claimed in one of claims 1 to 5, characterized in that the vehicle longitudinal speed is influenced by means of speed regulation.

7. The method as claimed in one of claims 1 to 6, characterized in that the vehicle (10) is retarded down to a standstill and is kept at a standstill as long as, on the basis of the existing steering angle deviation (d_{LW}), the vehicle (10) would assume a vehicle position during onward travel from which the target position (17) can no longer be reached without a shunting interruption to the driving maneuver.

8. The method as claimed in claim 7, characterized in that the vehicle (10) is accelerated again independently of the driver if the driver sets a steering wheel position which leads to a permissible steering angle deviation (d_{LW}).

9. The method as claimed in one of claims 1 to 8, characterized in that the steering wheel position to be set is indicated by means for acoustic driver information and/or means for optical driver information (13) and/or means for tactile driver information (40 and 41).

10. The method as claimed in claim 9, characterized is that the means for tactile driver information (40 and 41) have means for changing the steering wheel torque to be applied by the driver.

11. The method as claimed in one of claims 1 to 10, characterized in that the driving maneuver is a parking maneuver and the reference trajectory (16) indicates the ideal route from the actual vehicle position ($x_{F,act}/y_{F,act}/\psi_{F,act}$) into the parking position (17).

12. The method as claimed in one of claims 1 to 11, characterized in that, in the case of a vehicle (10) in trailer operation, each vehicle position along the actual reference trajectory (19) is assigned a desired trailer angle (β_{des}) between the vehicle longitudinal axis (71) and the trailer longitudinal axis (72), and in that the actual trailer angle (β_{act}) is determined and compared with the corresponding desired trailer angle (β_{des}), the vehicle longitudinal speed (v) being influenced independently of the driver in the event of an angular deviation between desired

trailer angle (β_{des}) and actual trailer angle (β_{act}).

13. A device for implementing a method for assisting the driver when performing a driving maneuver formed by a parking or shunting maneuver as claimed in one of claims 1 to 11, having means (12) for determining a reference trajectory (16) corresponding to the driving maneuver, and means (13; 40 and 41) for indicating the steering wheel position to be set by the driver and controlling the vehicle (10) along the reference trajectory (19), the vehicle longitudinal speed (v) being influenced by retardation means (50) and/or forward drive means (51) that can be activated independently of the driver if a steering angle deviation (d_{LW}) between the actual steering angle (δ_{act}) actually set by the driver and the desired steering angle (δ_{des}) corresponding to the requested steering wheel position is established in an evaluation device (12), characterized in that the vehicle longitudinal speed is influenced on the basis of the magnitude of the steering angle deviation (d_{LW}) in such a way that the greater the vehicle retardation carried out, the greater the magnitude of the steering angle deviation (d_{LW}).

14. The device as claimed in claim 13, characterized in that means (12) are provided for determining the desired trailer angle (β_{des}) between the vehicle longitudinal axis (71) and the trailer longitudinal axis (70), and means for determining the actual trailer angle (β_{act}), in that the evaluation device (12) compares the desired trailer angle (β_{des}) and the actual trailer angle (β_{act}), and in that the retardation means (50)

and/or forward drive means (51) of the vehicle (10) are activated in the event of an angular deviation being established between the desired trailer angle (β_{des}) and the actual trailer angle (β_{act}).

Fig. 1

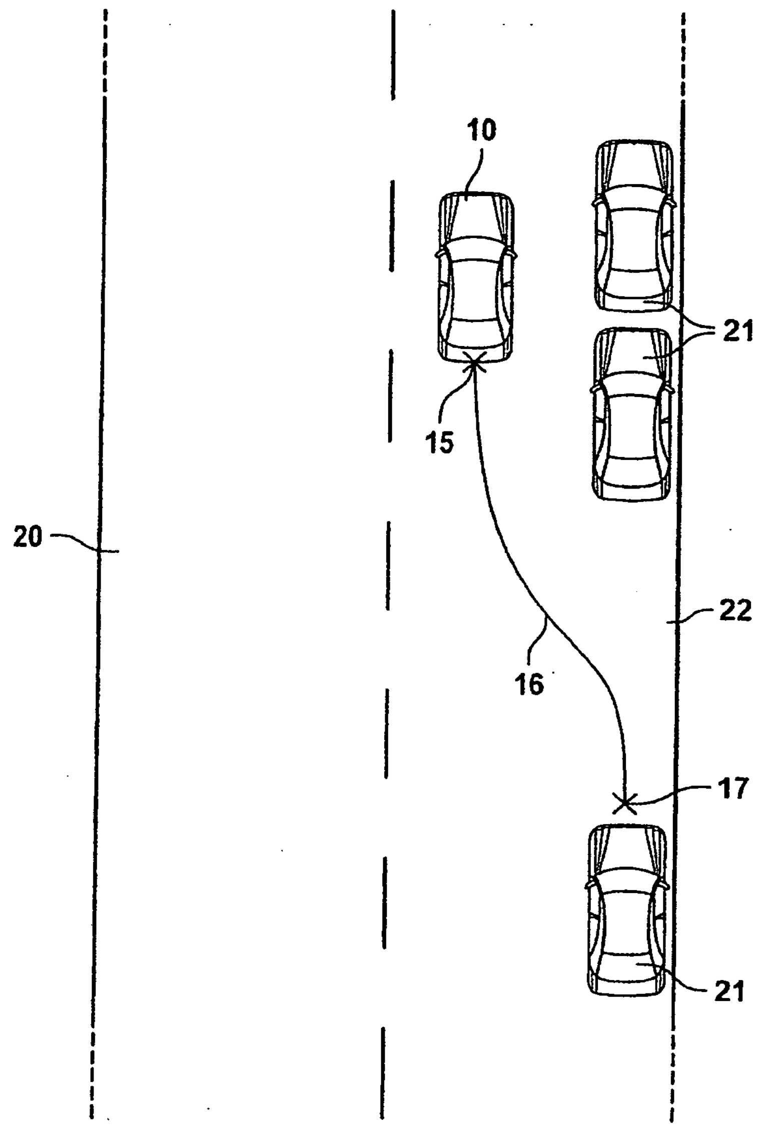

Fig. 2

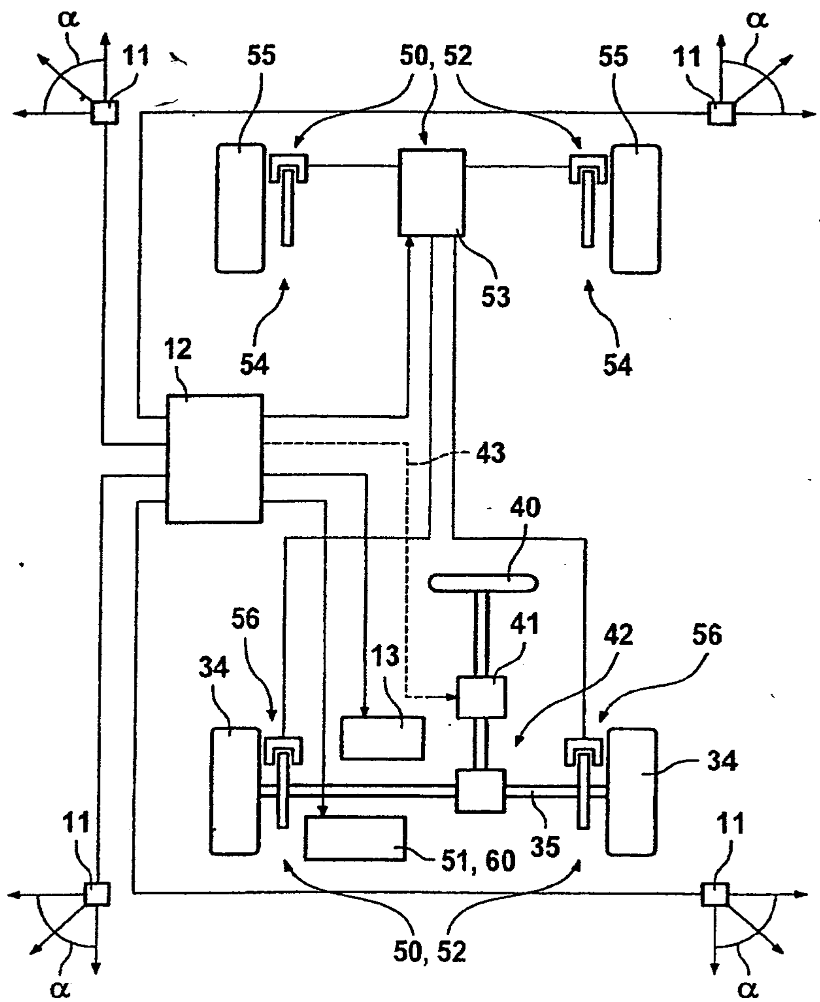
α
11
55
50, 52
55
11
α
53
54
54
12
43
40
56
41
42
56
34
13
34
35
11
51, 60
11
50, 52
α
α

Fig. 3a

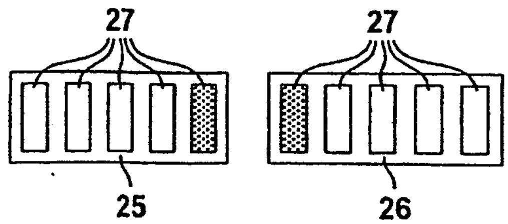

Fig. 3b

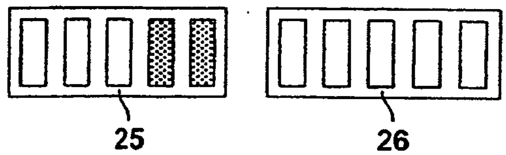

Fig. 3c

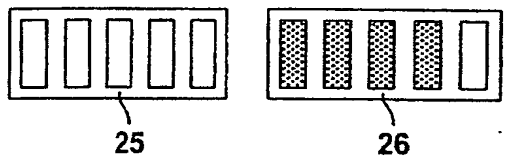

Fig. 4

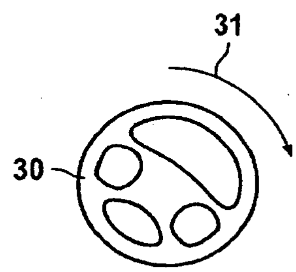

Fig. 5

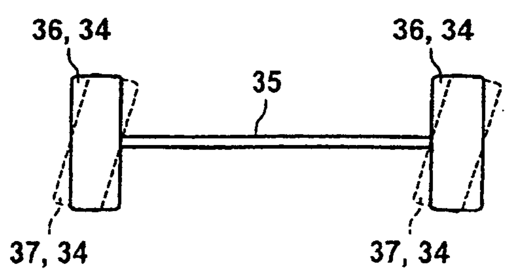

Fig. 6a

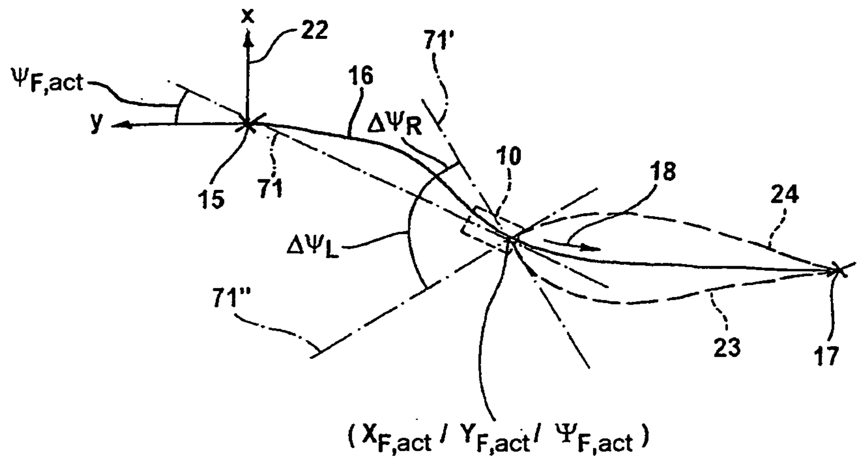
x
22
y
$\Psi_{F,act}$
16
71'
$\Delta\Psi_R$
10
18
24
15
71
$\Delta\Psi_L$
71"
23
17
($X_{F,act}$ / $Y_{F,act}$ / $\Psi_{F,act}$)

Fig. 6b

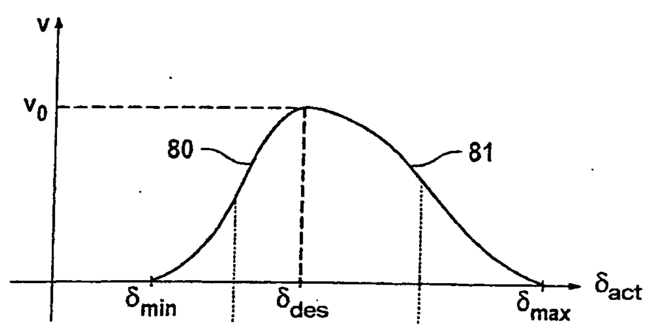
v
v_0
80
81
δ_{act}
δ_{min}
δ_{des}
δ_{max}

Fig. 7